(19) World Intellectual Property Organization International Bureau



(43) International Publication Date 20 December 2001 (20.12.2001)

PCT

(10) International Publication Number WO 01/96264 A1

(51) International Patent Classification⁷: B013 31/26

.....

C07C 1/06,

(21) International Application Number: PCT/US01/18997

(22) International Filing Date: 13 June 2001 (13.06.2001)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

60/211,084

13 June 2000 (13.06.2000) U

- (71) Applicant: CONOCO INC. [US/US]; McLean Building, 600 North Dairy Ashford, Suite 2084, Houston, TX 77210-4783 (US).
- (72) Inventors: SCHWARZ, Stephan; 507 Falkirk Road, Wilmington, DE 19803 (US). MASLOV, Sergej, A.; Apartment 517, 3536 Springwood Street, Ponca City, OK 74604 (US).
- (74) Agents: WESTPHAL, David; c/o Joanna Payne, 1000 South Pine, P.O. Box 1267, Ponca City, OK 74602-1267 et al. (US).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



264

(54) Title: FISCHER-TROPSCH PROCESSES AND CATALYSTS USING POLYACRYLATE MATRIX STRUCTURES

(57) Abstract: A Fischer-Tropsch catalyst comprising a catalytically active first metal selected from the group consisting of at least one metal selected from the group consisting of iron, nickel, cobalt, chromium, and mixtures thereof, at least one second metal selected from the group consisting of silver, iron, zinc, copper, platinum, zirconium and combinations thereof; and a matrix structure comprising a polymer selected from the group consisting of polyacrylates and polymethacrylates. The first and second metals are incorporated into the polymer.

WO 01/96264

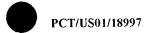
10

15

20

25

30



FISCHER-TROPSCH PROCESSES AND CATALYSTS USING POLYACRYLATE MATRIX STRUCTURES

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a process for the preparation of hydrocarbons from synthesis gas, *i.e.*, a mixture of carbon monoxide and hydrogen, typically labeled the Fischer-Tropsch process. More particularly, this invention relates to the use of acrylate polymer matrix structures for catalysts for the Fischer-Tropsch process. Still more particularly, the present invention relates to Fischer-Tropsch catalysts formed by polymerizing an acrylate with a catalytically active metal.

BACKGROUND

Large quantities of methane, the main component of natural gas, are available in many areas of the world, and natural gas is predicted to outlast oil reserves by a significant margin. However, most natural gas is situated in areas that are geographically remote from population and industrial centers. The costs of compression, transportation, and storage make its use economically unattractive. To improve the economics of natural gas use, much research has focused on the use of methane as a starting material for the production of higher hydrocarbons and hydrocarbon liquids, which are more easily transported and thus more economical. The conversion of methane to hydrocarbons is typically carried out in two steps. In the first step, methane is converted into a mixture of carbon monoxide and hydrogen (i.e., synthesis gas or syngas). In a second step, the syngas is converted into hydrocarbons.

This second step, the preparation of hydrocarbons from synthesis gas, is well known in the art and is usually referred to as Fischer-Tropsch synthesis, the Fischer-Tropsch process, or Fischer-Tropsch reaction(s). Fischer-Tropsch synthesis generally entails contacting a stream of synthesis gas with a catalyst under temperature and pressure conditions that allow the synthesis gas to react and form hydrocarbons.

More specifically, the Fischer-Tropsch reaction is the catalytic hydrogenation of carbon monoxide to produce any of a variety of products ranging from methane to higher alkanes and aliphatic alcohols. Research continues on the development of more efficient Fischer-Tropsch catalyst systems and reaction systems that increase the selectivity for high-value hydrocarbons in the Fischer-Tropsch product stream.

There are continuing efforts to find catalysts that are more effective at producing these desired products. Product distribution, product selectivity, and reactor productivity

10

15

20

25

30

depend heavily on the type and structure of the catalyst and on the reactor type and operating conditions. It is particularly desirable to maximize the production of high-value liquid hydrocarbons, such as hydrocarbons with five or more carbon atoms per hydrocarbon chain (C_{5+}) .

Catalyst supports for catalysts used in Fischer-Tropsch synthesis of hydrocarbons have typically been oxides (e.g., silica, alumina, titania, zirconia or mixtures thereof, such as silica-alumina). The products prepared by using these catalysts usually have a very wide range of molecular weights. It has been asserted that the Fischer-Tropsch synthesis reaction is only weakly dependent on the chemical identity of the metal oxide support (see E. Iglesia et al. 1993, In: "Computer-Aided Design of Catalysts," ed. E. R. Becker et al., p. 215, New York, Marcel Dekker, Inc.). Nevertheless, because it continues to be desirable to improve the activity of Fischer-Tropsch catalysts, other types of catalyst supports have been investigated.

The use of divinylbenzene cross-linked polystyrene as a support for Fischer-Tropsch catalysts is disclosed in U.S. Patent No. 4,292,415 and U.S. patent No. 4,725,568. Similarly, U.S. Pat. No. 4,230,633 discloses polymer supported metal complexes wherein the ligand is a cycloalkadienyl radical with metals from Group VIII of the Periodic Table. This patent relates to the conversion of carbon monoxide and hydrogen to hydrocarbons in a liquid reaction medium. Nevertheless, despite the research in this field, there is still a desire to identify new, more effective catalysts. In particular, catalysts that provide high C_{5+} and C_{11+} productivities are desired.

SUMMARY OF THE INVENTION

The present invention provides a catalyst system that is effective for producing C₅₊ and C₁₁₊ hydrocarbons. In accordance with a preferred embodiment, the present catalyst comprises (1) cobalt and at least one other metal selected from the group consisting of silver, iron, zinc and zirconium and (2) a matrix structure comprising a polymer selected from the group consisting of polyacrylates and polymethacrylates. The catalyst so formed is preferably treated with hydrogen at a temperature of at least 400°C prior to use. Catalyst systems constructed in accordance with the invention compare favorably to previously known catalysts in activity and durability.

The present invention further comprises a process for using the present catalyst system to produce hydrocarbons. The process comprises contacting a feed stream comprising hydrogen and carbon monoxide with the present catalyst system in a reaction

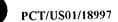
10

15

20

25

30



zone maintained at conditions that are effective to produce an effluent stream comprising hydrocarbons.

DETAILED DESCRIPTION

The present catalyst system comprises a catalytic composition integrated into a polymeric matrix structure. The catalytic composition preferably comprises at least one Group VIII metal, namely iron, nickel, cobalt, rhenium, ruthenium, chromium, and iridium or mixtures thereof, and at least one other metal selected from the group consisting of silver, iron, zinc and zirconium. Of these, cobalt/silver is most preferred. The catalytic composition may further include one or more promoters selected from the group consisting of alkali and alkaline earth metal in free or combined form, boron, and mixtures thereof.

The polyacrylate and polymethacrylate matrix structures used in the process of this invention can be prepared by the polymerization of metal acrylates and/or metal methacrylates. Several alternative techniques are suitable for achieving the desired polymerization.

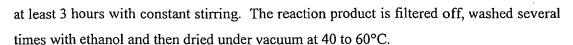
Formation of Cobalt acrylate

In one preferred technique, the present catalysts are formed by mixing the desired monomer with a salt of the desired metal catalyst and an initiator in a solvent. Polymerization occurs with mixing, producing a polymerized mass. The metal salt is preferably suspended in water and reacted with the acrylic acid or methacrylic acid at a temperature between about 40 and about 60°C. By way of example only, suitable metal salts include but are not limited to: basic cobalt carbonate, silver carbonate or silver oxide, iron carbonate or iron oxide, zinc carbonate or zinc oxide and zirconium carbonate or zirconium hydroxide. The reactions are carried out for about 5 hours with gradual addition of the acrylic acid or methacrylic and constant stirring. The solid product is extracted with ethanol and the extract is filtered and evaporated to dryness.

Technique I

The present catalysts can be prepared by dissolving a metal acrylate or metal methacrylate, such as cobalt acrylate, cobalt carbonate, or cobalt methacrylate (described above) and at least one other metal acrylate or methacrylate in methanol, ethanol or another suitable alcohol. The alcohol can contain as much as 25 wt % water. The polymerization is preferably carried out at reflux temperature using 2,2'-azobisisobutyronitrile as an initiator. The polymerization reaction mixture is refluxed for





Technique II

Alternatively, the present catalysts can be prepared by dissolving polyacrylic acid or polymethacrylic acid in water, followed by addition of the cobalt and at least one metal acrylate or metal methacrylate to the polymer solution under stirring. The solution gels and is evaporated to dryness.

Catalyst

5

10

15

20

25

30

The metal-containing polyacrylate or polymethacrylate catalysts produced by any of the preceding techniques are preferably reduced with hydrogen at a temperature of at least 400°C before use as a Fischer-Tropsch catalyst. Treatment with hydrogen activates the catalyst. Catalysts produced in this manner do not require supports.

Operation

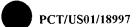
The present catalysts are preferably used in a Fischer-Tropsch reactor charged with feed gases comprising hydrogen or a hydrogen source and carbon monoxide. H₂/CO mixtures suitable as a feedstock for conversion to hydrocarbons according to the process of this invention can be obtained from light hydrocarbons such as methane by means of steam reforming or partial oxidation. The hydrogen is preferably provided by free hydrogen, although some Fischer-Tropsch catalysts have sufficient water gas shift activity to convert some water to hydrogen for use in the Fischer-Tropsch process. It is preferred that the mole ratio of hydrogen to carbon monoxide in the feed be greater than 0.5:1 (e.g., from about 0.67:1 to 2.5:1). The feed gas may also contain carbon dioxide or other compounds that are inert under Fischer-Tropsch reaction conditions, including but not limited to nitrogen, argon, or light hydrocarbons. The feed gas stream should contain a low concentration of compounds or elements which have a deleterious effect on the catalyst. The feed gas may need to be treated to ensure low concentrations of sulfur or nitrogen compounds such as hydrogen sulfide, animonia and carbonyl sulfides.

The feed gas is contacted with the catalyst in a reaction zone. Mechanical arrangements of conventional design may be employed as the reaction zone. For example, fixed bed, slurry phase, slurry bubble column, fluidized bed, or ebulliating bed reactors. Accordingly, the size of the catalyst particles may vary depending on the reactor in which they are to be used.

15

20

30



The process is typically run in a continuous mode. In this mode, typically, the gas hourly space velocity through the reaction zone may range from about 100 volumes/hour/volume catalyst (v/hr/v) to about 10,000 v/hr/v, preferably from about 300 v/hr/v to about 2,000 v/hr/v. The reaction zone temperature is typically in the range from about 160°C to about 300°C. Preferably, the reaction zone is operated at conversion promoting conditions at temperatures from about 190°C to about 260°C. The reaction zone pressure is typically in the range of about 80 psig (653 kPa) to about 1000 psig (6994 kPa), preferably, from 80 psig (653 kPa) to about 600 psig (4237 kPa), more preferably, from about 140 psig (1066 kPa) to about 400 psig (2858 kPa).

The reaction products will have a large range of molecular weights. The present catalysts are particularly useful for making hydrocarbons having five or more carbon atoms, especially when the above-referenced space velocity, temperature and pressure ranges are employed.

The wide range of hydrocarbon species produced in the reaction zone will typically result in liquid phase products at the reaction zone operating conditions. Therefore, the effluent stream of the reaction zone will often be a mixed phase stream. The effluent stream of the reaction zone may be cooled to effect the condensation of additional amounts of hydrocarbons and passed into a vapor-liquid separation zone. The vapor phase material may be passed into a second stage of cooling for recovery of additional hydrocarbons. The liquid phase material from the initial vapor-liquid separation zone together with any liquid from a subsequent separation zone may be fed into a fractionation column. Typically, a stripping column is employed first to remove light hydrocarbons The remaining hydrocarbons may be passed into a such as propane and butane. fractionation column wherein they are separated by boiling point range into products such as naphtha, kerosene and fuel oils. Hydrocarbons recovered from the reaction zone and having a boiling point above that of the desired products may be passed into conventional processing equipment such as a hydrocracking zone in order to reduce their molecular weight. The gas phase recovered from the reactor zone effluent stream after hydrocarbon recovery may be partially recycled if it contains a sufficient quantity of hydrogen and/or carbon monoxide.

Without further elaboration, it is believed that one skilled in the art can, using the description herein, utilize the present invention to its fullest extent. The following



embodiments are to be construed as illustrative, and not as constraining the remainder of the disclosure in any way whatsoever.

EXAMPLES

Catalyst Reduction

5

10

15

20

25

30

Each of the catalyst samples described below was treated with hydrogen as follows, prior to use in the Fischer-Tropsch reaction. The catalyst sample was placed in a small quartz crucible in a chamber and purged with 0.8 l/min nitrogen at room temperature for 15 minutes. The sample was then heated under 0.7 l/min hydrogen at 1°C/minute to 100°C and held at 100°C for one hour. The catalysts were then heated at 1°C/minute to 400°C and held at 400°C for four hours under 0.7 l/min hydrogen. The samples were cooled in hydrogen and purged with nitrogen before use.

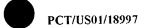
General Procedure For Batch Tests

For the batch tests, a 2 mL pressure vessel was heated at 225°C under 1000 psig (6994 kPa) of H₂:CO (2:1) and maintained at that temperature and pressure for 1 hour. In a typical run, roughly 50 mg of the hydrogen catalyst and 1 mL of n-octane was added to the vessel. After one hour, the reactor vessel was cooled in ice, vented, and an internal standard of di-n-butylether was added. The reaction product was analyzed on an HP6890 gas chromatograph. Hydrocarbons in the range of C₁₁-C₄₀ were analyzed relative to the internal standard. The lower hydrocarbons were not analyzed since they are masked by the solvent and are also vented as the pressure is reduced.

A C_{11+} Productivity (g C_{11+} /hour/kg catalyst) was calculated based on the integrated production of the C_{11} - C_{40} hydrocarbons per kg of catalyst per hour. The logarithm of the weight fraction for each carbon number $ln(W_n/n)$ was plotted as the ordinate vs. number of carbon atoms in (W_n/n) as the abscissa. The results of runs over a variety of catalysts at 225°C are set out below in Table 1.

Catalyst Preparation

Basic cobalt carbonate [CoCO₃[Co(OH)₂]_n·2H₂O] (40 g) was suspended in water (400 mL). Acrylic acid (25 mL) was added dropwise with stirring to the cobalt carbonate suspension and heated to 50-60°C in a waterbath. The black mass produced was extracted with ethanol, filtered, and evaporated to dryness yielding a purple solid, which was Coacrylate.



Example 1

A sample of the Co-acrylate (15.8 g) and Ag-acrylate (commercially available, 1 g) were dissolved in ethanol along with 2,2'-azobisisobutyronitrile (AIBN, 0.2 g) initiator. The mixture was refluxed for 3.5 hours. The brownish precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 400°C before use.

Example 2

5

10

15

20

25

30

Co-acrylate was dissolved in ethanol to prepare 25 mL of a solution containing 20 weight percent Co-acrylate, and placed in a 3-necked flask. Fe-acrylate (commercially available, 1 g) was dissolved in aqueous ethanol with stirring and heating and added to the flask. AIBN initiator (0.2 g) was added and the mixture was refluxed for 4 hours. The brown precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 400°C before use.

Example 3

Co-acrylate (6 g) was dissolved in ethanol and was placed in 3-necked flask. Zn-acrylate (commercially available, 1 g) was dissolved in aqueous ethanol with stirring and heating and added to the flask. AIBN initiator (0.2 g) was added and the mixture was refluxed for 4 hours. The pink-purple precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 400°C before use.

Example 4

Co-acrylate was dissolved in ethanol to prepare 25 mL of a solution containing 20 weight percent Co-acrylate, and placed in a 3-necked flask. Zr-acrylate (commercially available, 1 g) was dissolved in aqueous ethanol with stirring and heating and added to the flask. AIBN initiator (0.2 g) was added and the mixture was refluxed for 4 hours. The purple precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 400°C before use.

Example 5

Co-acrylate (5 g) was dissolved in ethanol to prepare 20 weight % Co acrylate solution and placed in a three-necked flask. Cr-acrylate (commercially available, 1 g) was dissolved in 75% aqueous ethanol with stirring and heating and added to the flask. AIBN initiator (0.2 g) dissolved in ethanol was added, and the mixture was refluxed for 4 hours.



The gray-blue precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 400°C before use.

Example 6

5

10

15

20

25

Co-acrylate (5 g) was dissolved in ethanol to prepare 20 weight % Co acrylate solution and placed in a three-necked flask. Cr-methacrylate (commercially available, 1 g) and Ag-methacrylate (commercially available, 1 g) were dissolved in 75% aqueous ethanol with stirring and heating and added to the flask. AIBN initiator (0.2 g) dissolved in ethanol was added, and the mixture was refluxed for 4 hours. The brown precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 400°C before use.

Example 7

Polyacrylic acid (commercially available, M.W. 250,000, 2.5 g) was dissolved in H₂O (60 mL). Ag-acrylate (0.1 g) was dissolved in aqueous ethanol (40 mL, 25% H₂O) and added to the polyacrylic acid solution. A Co-acrylate solution in ethanol (10 mL, 0.25g/mL) was added with stirring. The solution gelled and was evaporated to dryness. This material was reduced in hydrogen at 400°C before use.

 C_{11+} Productivity Ex. Catalyst 1 Poly(Co, Ag acrylate) 241 2 Poly(Co-Fe acrylate) 33.5 3 Poly(Co-Zn acrylate) 210 4 Poly(Co-Zr acrylate) 23.1 5 Poly(Co-Cr acrylate) 33.8 Poly(Co-acrylate/Cr-ethacrylate/ 6 67.5 Ag-methacrylate) 7 Polyacrylic acid/ Co, Ag-acrylate 142

TABLE 1

Comparative Example A

A sample of the Co-acrylate (3.1 g) was dissolved in ethanol (30 mL) along with 2,2'-azobisisobutyronitrile (AIBN, 0.06 g) initiator. The mixture was refluxed for 3.5 hours. The precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 50°C. The sample was reduced in hydrogen before use.

Comparative Example B

A sample of the Co-acrylate (15.8 g) and Ag-acrylate (commercially available, 1 g) were dissolved in ethanol along with 2,2'-azobisisobutyronitrile (AIBN, 0.2 g) initiator.

20



The mixture was refluxed for 3.5 hours. The brownish precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 200°C before use.

Comparative Example C

A sample of the Co-acrylate (15.8 g) and Ag-acrylate (commercially available, 1 g) were dissolved in ethanol along with 2,2'-azobisisobutyronitrile (AIBN, 0.2 g) initiator. The mixture was refluxed for 3.5 hours. The brownish precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C. This material was reduced in hydrogen at 300°C before use.

10 Comparative Example D

Polyacrylic acid (commercially available, M.W. 250,000, 2.0 g) was dissolved in H_2O (60 mL). The solution was evaporated to dryness. This material was reduced in hydrogen at 400°C before use.

Comparative Example E

Ethanolic Co-acrylate solution (20wt% Co-acrylate in ethanol, 25 mL) was placed in a 3-necked flask. Cu-acrylate (commercially available, 1 g) was dissolved in aqueous ethanol with stirring and heating and added to the flask. AIBN initiator (0.1 g) was added and the mixture was refluxed for 4 hours. The gray precipitate was filtered, washed with warm ethanol and dried in a rotary evaporator at 55°C before use.

None of the materials prepared in Comparative Example A to E were catalytically active.

CLAIMS

What is claimed is:

1. A process for producing hydrocarbons, comprising contacting a feed stream comprising hydrogen and carbon monoxide with a catalyst in a reaction zone maintained at conversion-promoting conditions effective to produce an effluent stream comprising hydrocarbons, wherein the catalyst comprises:

a catalytically active first metal selected from the group consisting of at least one metal selected from the group consisting of iron, nickel, cobalt, chromium, and mixtures thereof;

at least one second metal selected from the group consisting of silver, iron, zinc and zirconium and combinations thereof; and

a matrix structure comprising a polymer selected from the group consisting of polyacrylates and polymethacrylates;

wherein the first and second metals are incorporated into the polymer.

15

10

- 2. The process of claim 1 wherein the first metal is cobalt.
- 3. The process of claim 2 wherein the second metal is silver.
- 4. The process of claim 1 wherein the first metal comprises from about 0.1 to 50 mole percent of the matrix metal and catalyst metal combined.
 - 5. The process of claim 4 wherein the first metal comprises from about 10 to 50 mole percent of the matrix metal and catalyst metal combined.

25

6. The process of claim 1 wherein the catalyst comprises a polymer selected from the group consisting of poly(Co,Ag-acrylate), poly(Co-Fe acrylate), poly(Co-Zn acrylate), poly(Co-Zr acrylate), poly(Co-Cr acrylate), poly(Co-acrylate/Cr-ethacrylate/Agmethacrylate) and polyacrylic acid/ Co,Ag-acrylate.

30

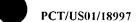
7. The process of claim 6 wherein the polymer is pretreated in hydrogen.

10

15

20

30



8. The process of claim 6 wherein the polymer is pretreated in hydrogen at a temperature above 300°C for at least 0.5 hours.

- 9. A Fischer-Tropsch catalyst comprising:
 - a catalytically active first metal selected from the group consisting of at least one metal selected from the group consisting of iron, nickel, cobalt, chromium, and mixtures thereof;

at least one second metal selected from the group consisting of silver, iron, zinc and zirconium and combinations thereof; and

a matrix structure comprising a polymer selected from the group consisting of polyacrylates and polymethacrylates;

wherein the first and second metals are incorporated into the polymer.

- 10. The catalyst of claim 9 wherein the first metal is cobalt.
- 11. The catalyst of claim 10 wherein the second metal is silver.
- 12. The catalyst of claim 9 wherein the first metal comprises from about 0.1 to 50 mole percent of the matrix metal and catalyst metal combined.
- 13. The catalyst of claim 10 wherein the first metal comprises from about 10 to 50 mole percent of the matrix metal and catalyst metal combined.
- 14. The catalyst of claim 9 wherein the catalyst comprises a polymer selected from the group consisting of poly(Co,Ag-acrylate), poly(Co-Fe acrylate),poly(Co-Zn acrylate), and poly(Co-Zr acrylate), poly(Co-acrylate/Cr-ethacrylate/Ag-methacrylate) and polyacrylic acid/ Co,Ag-acrylate.
 - 15. The catalyst of claim 14 wherein the polymer is pretreated in hydrogen.
 - 16. The catalyst of claim 14 wherein the polymer is pretreated in hydrogen at a temperature above 300°C for at least 0.5 hours.



- 17. A method for preparing a Fischer-Tropsch catalyst comprising:
 - (a) providing a catalytically active first metal selected from the group consisting of at least one metal selected from the group consisting of iron, nickel, cobalt, chromium, and mixtures thereof;
- (b) providing at least one second metal selected from the group consisting of silver, iron, zinc and zirconium and combinations thereof; and
 - (c) providing a polymer precursor; and
- (d) polymerizing the polymer precursor in the presence of said first and second metals to form a polymer, such that the first and second metals are incorporated
 into the polymer.
 - 18. The method of claim 17 wherein the polymer is selected from the group consisting of polyacrylates and polymethacrylates.
- 15 19. The method of claim 18 further including treating the polymer in hydrogen.
 - 20. The method of claim 18 further including treating the polymer in hydrogen at a temperature above 300°C for at least 0.5 hours.
- 20 21. The method of claim 17 wherein the first metal is cobalt.
 - 22. The method of claim 21 wherein the second metal is silver.
- 23. The method of claim 17 wherein the first metal comprises from about 0.1 to 50 mole percent of the matrix metal and catalyst metal combined.
 - 24. The method of claim 17 wherein the first metal comprises from about 10 to 50 mole percent of the matrix metal and catalyst metal combined.
- 25. A process for producing hydrocarbons by contacting a feed stream comprising hydrogen and carbon monoxide with a catalyst in a reaction zone maintained at conversion-promoting conditions effective to produce an effluent stream comprising said hydrocarbons, characterized by using a catalyst prepared by the method of claim 17.

10



- 26. The process of claim 25 wherein the first metal is cobalt.
- 27. The process of claim 26 wherein the second metal is silver.
- 28. The process of claim 25 wherein the polymer is selected from the group consisting of polyacrylates and polymethacrylates.
- 29. The process of claim 25 further including treating the polymer in hydrogen.
- 30. The process of claim 25, further including treating the polymer in hydrogen at a temperature above 300°C for at least 0.5 hours.
- 31. The method of claim 17 wherein step (c) produces a catalyst comprising a polymer selected from the group consisting of poly(Co,Ag-acrylate), poly(Co-Fe acrylate), poly(Co-Zn acrylate), and poly(Co-Zr acrylate), poly(Co-acrylate/Cr-ethacrylate/Ag-methacrylate) and polyacrylic acid/ Co,Ag-acrylate.

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 C07C1/06 B01J31/26								
According to International Patent Classification (IPC) or to both national classification and IPC								
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols)								
IPC 7 CO7C C10G								
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched								
Electronic d	data base consulted during the international search (name of data	base and, where practical, search terms used						
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal								
C. DOCUM	ENTS CONSIDERED TO BE RELEVANT							
Category °	Citation of document, with indication, where appropriate, of the	relevant passages	Relevant to claim No.					
A	EP 0 005 569 A (SHELL INTERNATI RESEARCH MAATSCHAPPIJ) 28 November 1979 (1979-11-28) claim 15	ONALE	1					
Fur	ther documents are listed in the continuation of box C.	χ Patent family members are listed	I in annex.					
Special c	ategories of cited documents :							
A document defining the general state of the art which is not considered to be of particular relevance *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention								
filing		"X" document of particular relevance; the cannot be considered novel or cannot	t be considered to					
*L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *Y' document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the								
other	*O* document referring to an oral disclosure, use, exhibition or other means document is combined with one or more other such document of the such document is combined with one or more other such document, such combination being obvious to a person skilled							
	nent published prior to the international filing date but than the priority date claimed	in the art. '&' document member of the same paten	I family					
Date of the actual completion of the international search Date of mailing of the international search report								
	5 November 2001	13/11/2001						
Name and	I mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–3016 Fay: (+31–70) 340–3016	Authorized officer Van Geyt, J						

INTERNATIONAL SEARCH REPORT mation on patent family members

1	Application No
PCT	01/18997

EP 0005569 A 28-11-1979 US 4179402 A 18-12-1979 BR 7902937 A 04-12-1979 CA 1131608 A1 14-09-1982 CS 225815 B2 13-02-1984 DD 155957 A5 21-07-1982 DE 2961215 D1 14-01-1982 EP 0005569 A1 28-11-1979 ES 480574 A1 16-07-1980 JP 1466873 C 10-11-1988 JP 54149392 A 22-11-1979 JP 63015017 B 02-04-1988 PL 215564 A1 25-02-1980 US 4317936 A 02-03-1982 YU 112779 A1 28-02-1983	Patent document cited in search report		Publication date	Patent family member(S)		Publication date
	EP 0005569	A	28-11-1979	BR CS DD DE EP ES JP JP PL US	7902937 A 1131608 A1 225815 B2 155957 A5 2961215 D1 0005569 A1 480574 A1 1466873 C 54149392 A 63015017 B 215564 A1 4317936 A	04-12-1979 14-09-1982 13-02-1984 21-07-1982 14-01-1982 28-11-1979 16-07-1980 10-11-1988 22-11-1979 02-04-1988 25-02-1980 02-03-1982